Citation: Aftab, M., Ahmad, R., Ismail, I. and Phylaktis, K. ORCID: 0000-0001-9392-1682 (2020). Economic Integration and the Currency and Equity Markets Nexus. International Journal of Finance and Economics, doi: 10.1002/ijfe.2065

Received: 23 July 2019 | Revised: 24 June 2020 | Accepted: 24 June 2020
DOI: 10.1002/ijfe.2065

RESEARCH ARTICLE

WILEY

Economic integration and the currency and equity markets nexus

Aftab Muhammad[1] | **Ahmad Rubi**[2] | **Izlin Ismail**[2] | **Kate Phylaktis**[3]

[1]Department of Management Sciences, COMSATS University Islamabad, Islamabad, Pakistan

[2]Department of Finance and Banking, Faculty of Business and Accountancy, University of Malaya, Kuala Lumpur, Malaysia

[3]Faculty of Finance, Cass Business School, City University of London, London, UK

Correspondence
Kate Phylaktis, Faculty of Finance, Cass Business School, City, University of London, 106 Bunhill Row, London, EC1Y 8TZ, UK.
Email: k.phylaktis@city.ac.uk

Abstract
The paper examines the impact of economic integration on the relationship between the currency and equity markets for a group of Asian emerging economies using both linear and non-linear frameworks. We first derive the dynamic conditional correlations between the two markets and then examine the impact of economic integration on their relationship. Our main results are: (a) there is a negative correlation between real exchange rate changes and equity return differentials for all countries apart from China, which becomes deeper during the global financial crisis (GFC) for some of the countries; (b) economic integration, both real and financial, has an asymmetric impact on the relationship between the two markets both in the short-run and in the long-run; and (c) applying a linear framework does not bring out the impact of financial integration.

KEYWORDS
dynamic conditional correlations, economic integration, real exchange rate changes, stock return differentials

JEL CLASSIFICATION
F31; G15

1 | INTRODUCTION

Capital flight, exchange rate fluctuations, and the transition to a market-based economy are major relevant issues for the dynamics between currency and equity markets in the emerging Asian economies. Though capital inflows to Asian emerging markets have been high (Milesi-Ferretti & Tille, 2011), they have remained sensitive to repatriations and portfolio reallocations (Bussière, Schmidt, & Valla, 2018; Crockett, 2002). These fluctuations have the potential to cause shocks to currency markets, with market-wide effects, and trigger a financial crisis, which can spread across the region in the current era of economic integration, such as the episode of the 1998 Asian Financial Crisis. This is a great policy concern for policymakers and regulators in Asia, who are trying to ensure financial and economic stability (Chkili & Nguyen, 2014). On the other hand, after the adoption of more flexible exchange rate regimes,[1] high exchange rate fluctuations have been a challenge for international investors and fund managers to formulate an effective global asset allocation strategy for the emerging Asian markets. In the presence of higher currency risk, the benefits of comparatively higher stock returns may be offset by currency fluctuations and a satisfactory return may not be obtained without controlling for the currency effects (Driessen & Laeven, 2007).[2]

In this paper, we attempt to capture the dynamics of the currency and equity markets through the use of a dynamic conditional correlation (DCC) estimation method, to reflect the volatility of capital flows of recent times and the global financial crisis (GFC), which have resulted in time-varying relationships. Our sample period is 2005–2016, which covers the build-up of capital flows during the 2000s and the subsequent collapse after the GFC. Our second objective is to examine the impact of the globalization process on those dynamics and to consider its possible non-linear, or asymmetric effects.

Numerous studies have investigated the dynamics of the two markets. However, many of those studies are based on the cointegration approach (see e.g., Nieh & Lee, 2001; Phylaktis & Ravazzolo, 2005) which is appropriate for studying long-run relationships but is less suitable for studying the short-to-medium-term relationships of these markets (Hau & Rey, 2006). Furthermore, equity and currency markets behave in a time-varying and volatile manner, which is also not captured by the cointegration approach.[3] These aspects of the dynamics emphasize the need to constantly rebalance the portfolios to exploit the benefits of diversification. Very few studies consider the time-varying behaviour of the currency and equity markets nexus.[4] As such, this research employs DCC-GARCH proposed by Engle (2002). This approach not only takes into account the heteroscedasticity issue of financial time series but also handles directly the time-varying relationships. This constitutes our first contribution.

However, our main contribution is the examination of the impact of economic integration on the currency and equity markets nexus using a non-linear asymmetric framework to capture the non-linearities found in many underlying variables.

Few studies have examined the determinants of the association between currency and equity markets. For example, Hau and Rey (2006) using a sample of 17 OECD economies over the period 1980–2001 consider the effects of financial development measured by market capitalization to GDP and find that correlations between the two markets are higher for countries with high financial development. J.-W. Cho, Choi, Kim, and Kim (2016) using a sample of nine developed and 12 emerging markets over the period 1996–2009 examine the impact of capital flight and find that conditions in the global equity markets define the inflows and outflows of capital in the emerging and advanced economies. During the downturn of global markets, capital moves from the emerging to the advanced economies resulting in depreciation (appreciation) of the emerging markets (advanced) currencies. Therefore, the flow of capital from the emerging markets to the developed markets during the recent financial crisis explains the exchange rate and equity returns association. In this way, the authors find that currency and equity markets have positive (negative) correlations in emerging (advanced) markets and capital flows substantiate the relationship.

Moore and Wang (2014) examine the impact of economic integration on the correlation between the exchange rate and equity markets for a group of Asian emerging markets, namely Indonesia, Malaysia, South Korea, the Philippines, Singapore and Thailand, and a group of developed markets, Australia, Canada, Japan, and the UK, using quarterly data over the period 1980–2006. Interestingly, they find that the trade route is an important channel in determining the nexus in emerging markets while the interest rate differential route is important in determining the relationship in advanced countries. The significance of interest rate differentials depicts the vital effect of capital mobility.

This study focuses also on the Asian emerging economies but includes the two biggest emerging market economies, namely China and India, which constitute altogether17.35% of the global economy, and covers the period 2005–2016 which includes the GFC.[5] It considers the linear and non-linear role of real and financial integration in explaining the currency and equity market correlations. Economic linkages between the Asian and the advanced economies have increased after the adoption of liberalisation policies in Emerging Asia, which in turn have increased economic integration with the rest of the world (S. Narayan, Sriananthakumar, & Islam, 2014). Previous studies on the impact of economic integration were based on a linear, or symmetric approach, which might have given rise to misleading results if the linear assumption did not hold, something we found to be the case in our study.[6]

Non-linearity is an important aspect of macroeconomic variables. Keynes (1936) noted that macroeconomic variables can shift suddenly from an expansionary state to a recessionary state. However, he also noted that the turning point in the opposite direction from a recessionary to the expansionary phase is not frequent and is slower in macroeconomic variables. This dissimilarity in the variables shifting from different states over a period has given rise to the need to model asymmetry and non-linearity in order to improve our understanding of long-term relationships between macroeconomic variables (Shiller, 2005; Shin, Yu, & Greenwood-Nimmo, 2014).

In the recent literature, a consensus is emerging to look into the non-linear patterns of the relationships to better understand the underlying dynamics (e.g., Bahmani-Oskooee & Fariditavana, 2015; Choudhry & Hassan, 2015). Economic integration is a macroeconomic phenomenon and may show a non-linear or asymmetric effect in explaining the association between currency and equity markets. Besides, financial markets are largely based on expectations, and in the case when a particular expectation dominates in a market, the response is prone to non-linearity, or asymmetry (Bahmani-Oskooee and Saha, 2015; Bahmani-Oskooee & Fariditavana, 2015). The asymmetric analysis applied in this study disaggregates changes in economic integration into increases and decreases and looks into the effects of each one on the currency-equity markets nexus.

Our main results can be summarized as follows: We find a negative correlation between real exchange rate changes and equity return differentials for all countries apart from China, which becomes deeper for some of the countries during the GFC. Secondly, economic integration, both real and financial, has an asymmetric impact on the relationship between the two markets, both in the short-run and in the long-run. Thirdly, applying a linear framework does not bring out the impact of financial integration.

The rest of the paper is arranged as follows. Section 2 discusses the theoretical underpinnings of the equity and currency markets nexus and the importance of economic integration in that relationship. Section 3 presents the data and preliminary analysis, while Section 4 presents the empirical results of the DCC between the two markets. Section 5 investigates the impact of economic integration on that relationship. Finally, Section 6 concludes the paper.

2 | THEORETICAL UNDERPINNINGS

2.1 | The currency and equity markets nexus

The classical, as well as the modern theories, are contradictory in terms of their different implications on the association between the currency and equity markets. For example, in the classical theory, the "portfolio" approach describes that the stock price has an effect on the exchange rate through the capital account (Branson, 1981; Frankel, 1983; Gavin, 1989). For example, an increase in the stock prices in Malaysia will increase wealth, the demand for money, and interest rates, leading to an appreciation of the Malaysian Ringgit[7] and a decrease in the real exchange rate[8] resulting in a *negative* association with stock price differential.[9] Contrary to the "portfolio" approach, the "flow" oriented model states that the exchange rate associates with stock price through the variations it causes to international competitiveness (Dornbusch & Fischer, 1980). For example, an increase in international competitiveness, say through a depreciation of the Malaysian Ringgit(an increase in the nominal exchange rate) and an increase in the real exchange rate affects the trade balance and the real sector performance favourably, which is also reflected in the stock prices, as firm stock prices reflect expected future cash flows, which are influenced by the future internal and external aggregate demand producing a *positive* association with the stock price differential.

Similarly, modern theory has different predictions on the relationship. For example, Malliaropulos (1998) predicts that the improvement in equity market performance associates with real exchange rate appreciation, which is a *negative* association between the real exchange rate and the stock price differential. In other words, when the domestic equity market (e.g., Malaysia) outperforms the foreign equity market (e.g., the US), the exchange rate appreciates (i.e., value of Malaysian ringgit improves relative to US dollar). On the other hand, Hau and Rey (2006) develop a model which shows that in the case when the investors cannot hedge the currency exposure perfectly and follow portfolio rebalancing strategies; namely, any surge in foreign (US) vis-à-vis domestic (Malaysian) equity returns induces Malaysian investors to repatriate some of their foreign-equity wealth due to a desire to reduce their FX exposure which, in turn, induces the foreign currency to depreciate. Thus, an increase in US stock prices relative to the Malaysian stock prices will be associated with a depreciation of the dollar (an appreciation of the Malaysian Ringgit) and a decrease in the real exchange rate giving rise to a *positive* association between the real exchange rate and the stock price differential for Malaysia.

Noting the contradictions in the theory, this paper seeks to provide empirical evidence on the dynamics between currency and equity markets for a group of Asian emerging economies, which comprise a high proportion of the global economy, 17.35% of the global economy.

2.2 | Economic integration and the linkage between the currency and equity markets

The increase in international linkages as a result of financial liberalisation, including the relaxation of foreign asset ownership restrictions, the development of the capital markets along with the macroeconomic and trade reforms in these countries have made the financial market relationships more complicated (Dai, 2014) and this motivates our research to reexamine the existing relationships and to investigate the influence of economic integration on the association between currency and equity markets. Economic integration takes place through two channels, trade of goods and the current account and relate to the abolition of trade barriers and is referred to as real integration; and capital flows and the capital account and relates to the abolition of capital flow restrictions and is referred to as financial integration. The role of economic integration has evolved significantly through the fast process of liberalisation of trade and capital flows across the globe (Bekaert & Harvey, 2017) and has impacted the complexity of financial markets, which makes it imperative to investigate its impact on the currency-equity markets nexus.

From the theoretical models outlined earlier, one can see how economic integration may affect the association between currency and equity markets. For example, the flow-oriented model provides a supportive argument to this link. Real integration is related to the international competitiveness of the real economy, and the flow-oriented model shows the influence of the current account changes on the exchange rate and stock prices. Similarly, financial integration is associated with the foreign ownership of assets and the portfolio-oriented model shows the influence of the capital account variations on stock prices and exchange rates.

Following the liberalisation era, the pace of trade and financial integration has improved in emerging Asian economies. The trade linkage is very dominant in the emerging economies due to the latter's over-reliance on export-led growth policies. Trade constitutes a large part of their gross domestic product. For example, the Malaysian foreign trade ratio[10] is 141.6, (74.4% for exports and 67.2% for imports).[11] Similarly, with the development of stock markets and the liberalisation of the capital account in the emerging economies, financial integration has increased. As a result, we expect to find a significant influence of real and financial integration on the association between currency and equity markets.

3 | DATA

This study considers nine Asian emerging economies namely; China, Korea, India, Indonesia, Malaysia, Pakistan, the Philippines, Singapore, and Thailand, which constitute 17.35% of the global economy. Our sample includes two of the biggest emerging markets, namely China and India, which are very important players globally, as well as in the region. These economies are classified as emerging economies by Morgan Stanley Capital International (MSCI).[12] The sample spans the period from July 2005 to December 2016,[13] which includes the buildup of financial flows in the global economy and the outburst of the GFC. All the data are sourced from Datastream, IMF Financial Statistics, and Federal Reserve Bank of St. Louis Economic Research database. For details of the definitions and sources of data see Table A1. We use monthly data to capture dynamic relationships more accurately.[14]

3.1 | Preliminary analysis

Table 1 provides a preliminary analysis of our main variables, the equity return differentials, and the real exchange rate changes. As can be seen, the mean as well as the standard deviation, which measures the volatility, are higher for equity return differentials compared to real exchange rate changes.[15] The Jarque–Bera test, which is a test for normality with a null hypothesis of normality presence, rejects the null hypothesis at the *p*-value of 10%, or below and establishes the absence of normality in many of the series (Table 1, Panel A).

We test the stationarity of our series using the Augmented Dickey-Fuller (ADF) test with a null hypothesis of unit root/non-stationary (Table 1, Panel B). As can be seen, all the data series for both stock return differentials and real exchange rate changes reject the null hypothesis of unit root at the 1% level of statistical significance at level-intercept and trend restrictions. This fulfils the DCC-GARCH assumption that the series should be stationary.

Serial correlation is also an important issue in financial time series. We use the Ljung-Box-Pierce Q-test to examine the serial correlation properties of the data with the null hypothesis of no autocorrelation. The lag order of the series is selected based on $min\left(\left[\frac{n}{2}\right]-2,40\right)$ criterion. The results reported in Table 1, Panel C show that serial correlation is present in all the equity return differentials and real exchange rate changes series when applied to the residuals in both level and square forms.

4 | METHODOLOGY

This research consists of two stages. In the first stage, we estimate the DCC between the equity stock price differential and the real exchange rate changes (Section 4.1), and in the second stage, we examine the impact of economic integration on the relationship (Section 5).

4.1 | The dynamic conditional correlation

The serial dependence noted above makes the use of the generalized autoregressive conditional heteroskedasticity

TABLE 1 Summary statistics

	China	India	Indonesia	Korea	Malaysia	Philippines	Pakistan	Singapore	Thailand
Panel A: Descriptive statistics									
I. Equity return differentials[a]									
Mean	0.0029	0.0031	0.0027	0.0015	0.0009	0.0026	0.0028	0.0003	0.0015
SD	0.041	0.0307	0.028	0.0233	0.0159	0.0248	0.0327	0.0233	0.026
Min.	−0.1232	−0.1306	−0.1269	−0.1139	−0.07	−0.1098	−0.1813	−0.1236	−0.1506
Max.	0.1073	0.1182	0.0761	0.0539	0.0561	0.0711	0.0865	0.0815	0.0578
J.B.	15.06 (.0005)**	17.25 (.0002)**	23.57 (.0000)**	26.81 (.0000)**	19.58 (.0001)**	21.98 (.0000)**	49.52 (.0000)**	36.66 (.0000)**	50.07 (.0000)**
II. Real exchange rate changes[b]									
Mean	−0.0005	0.0002	−0.0011	−0.0003	−0.0004	−0.0018	−0.0014	−0.0012	−0.0011
SD	0.0039	0.0111	0.014	0.0156	0.0101	0.0081	0.0057	0.0084	0.0078
Min.	−0.0113	−0.0385	−0.046	−0.0668	−0.0299	−0.0196	−0.0324	−0.0193	−0.0217
Max.	0.0172	0.0364	0.0945	0.0573	0.0407	0.0236	0.0207	0.0358	0.0179
J.B.	19.52 (0.0001)**	9.51 (.0086)**	65.73 (.0000)**	16.25 (.0003)**	16.63 (.0002)**	1.09 (.5803)	27.58 (.0000)**	12.85 (.0016)**	1.4 (.496)
Panel B: Unit root analysis									
I. Equity return differentials									
Int.	−11.462 (.0000)**	−10.558 (.0000)**	−9.72 (.0000)**	−11.879 (.0000)**	−10.202 (.0000)**	−10.632 (.0000)**	−10.72 (.0000)**	−9.736 (.0000)**	−10.03 (.0000)**
Trend	−11.453 (.0000)**	−10.61 (.0000)**	−9.713 (.0000)**	−11.89 (.0000)**	−10.21 (.0000)**	−10.59 (.0000)**	−10.83 (.0000)**	−9.732 (.0000)**	−10.03 (.0000)**
II. Real exchange rate changes									
Int.	−9.213(.0000)**	−12.124(.0000)**	−12.366(.0000)**	−12.893(.0000)**	−11.418(.0000)**	−10.743(.0000)**	−11.42 (.0000)**	−12.39 (.0000)**	−9.43 (.0000)**
Trend	−9.75(.0000)**	−12.082(.0000)**	−12.488(.0000)**	−12.856(.0000)**	−11.847(.0000)**	−10.749(.0000)**	−11.94 (.0000)**	−12.68 (.0000)**	−9.703 (.0000)**
Panel C: Ljung–Box–Pierce Q-test for serial correlation									
I. Equity return differentials									
Level	57.884 (.0334)**	82.522 (.0001)**	88.228 (.0000)**	89.377 (.0000)**	79.323 (.0002)**	67.867 (.0061)**	80.422 (.0002)**	79.044 (.0002)**	84.211 (.0000)**
Square	80.3116 (.0002)**	58.8841 (.0274)**	63.9706 (.0094)**	61.3584 (.0165)**	66.5041 (.0022)**	54.0942 (.0599)*	81.5574 (.0001)**	71.876 (.0019)**	87.3408 (.0000)**
II. Real exchange rate changes									
Level	85.2535 (.0000)**	72.148 (.0014)**	75.0852 (.0009)**	65.6782 (.0248)**	68.5625 (.0135)**	80.2342 (.0004)**	83.2037 (.0003)**	75.961 (.0009)**	82.9189 (.0000)**
Square	71.628 (.0001)**	64.635 (.0081)**	87.608 (.0000)**	185.554 (.0000)**	80.1136 (.0002)**	81.1795 (.0000)**	54.9547 (.0579)*	60.725 (.0195)**	71.824 (.0019)**

Note: Panel A reports the descriptive statistics, Panel B, the unit root results and panel C the serial correlation results of equity return differentials and real exchange rate changes. *p*-values are in the parentheses. **(*) shows significance at 5% (10%).

[a]Equity return differential is the difference of price adjusted equity returns ($P_t = \log(P_t/P_{t-1})$) between the sample market and the US equity market in terms of sample market currency. This study takes US as a reference market because it works as a conduit to link the world financial markets (Phylaktis & Ravazzolo, 2005). The equity index used for the US market is Standard and Poor Composite Index (S&PCOMP) and for the sample equity markets the indices are Shanghai Composite Index, Korea Composite Stock Price Index, Bombay Stock Exchange 100 Index, Indonesia Composite Index, FTSE Bursa Malaysia Kuala Lumpur Stock Exchange Composite Index, Karachi Stock Exchange 100 index, Philippines Stock Exchange Composite Index (PSECI), Strait Times Index (STI), Bangkok Stock Exchange of Thailand index (BSETI). This strategy captures the global influences on the emerging Asian equity markets.

[b]Real exchange rate changes (XR) are measured by taking log first difference of real exchange rate (REX). That is, $XR_t = \log(REX_t/REX_{t-1})$. Exchange rate is defined as national currency per unit of foreign currency (i.e., US dollar). For example, for Malaysia, RM/USD. The nominal exchange rate (NEX) is adjusted for relative prices to get REX. For example, $REX_t = (NEX_t)(CPI^{US}/CPI_t^{ML}$, where CPI is consumer price index, superscript US and ML denote US and Malaysia, respectively. Following nine currencies are used; Chinese yuan, Korean won, Indian rupee, Indonesian rupiah, Malaysian ringgit, Pak rupee, Pilipino peso, Singaporean dollar, and Thai baht. For the exchange rate of each of these currencies, numeraire currency is US dollar.

TABLE 2 DCC-MGARCH estimates

	China	India	Indonesia	Korea	Malaysia	Pakistan	Philippines	Singapore	Thailand
Equity return differentials									
ϑ	.0005 (.097)	.0001 (.456)	.0004 (.001)	.0001 (.544)	.0001 (.304)	.0001 (.001)	.0022 (.217)	.0077 (.266)	.0004 (.181)
γ_{i1}	.0141 (.0000)	.1389 (.063)	.3403 (.021)	.0886 (.162)	.1339 (.091)	.0175 (.096)	.1306 (.062)	.2905 (.161)	.1318 (.088)
δ_{i1}	.6447 (.0000)	.8304 (.000)	.0282 (.0001)	.9119 (.000)	.8239 (.000)	.7702 (.001)	.8443 (.000)	.5792 (.019)	.7804 (.000)
Real exchange rate changes									
ϑ	.0001 (.006)	.0001 (.077)	.0004 (.008)	.0001 (.043)	.0012 (.317)	.002 (.000)	.0331 (.239)	.0001 (.12)	.007 (.932)
γ_{i1}	.0673 (.128)	.2416 (.067)	.5785 (.034)	.327 (.01)	.1476 (.019)	.0262 (.000)	.071 (.090)	.0756 (.2)	.0707 (.0654)
δ_{i1}	.6849 (.131)	.6701 (.000)	.2955 (.018)	.3421 (.045)	.8192 (.000)	.182 (.019)	.8878 (.000)	.7673 (.000)	.8169 (.3212)
DCC parameters									
φ_1	.0106 (.052)	.0482 (.341)	.0541 (.005)	.0685 (.175)	.1241 (.032)	.0076 (.083)	.0363 (.256)	.1465 (.343)	.0062 (.562)
ω_1	.355 (.000)	.8192 (.000)	.372 (.0001)	.7038 (.000)	.483 (.0031)	.6481 (.043)	.9239 (.000)	.335 (.146)	.9696 (.000)
Diagnostics									
Log likelihood	840.375	759.6969	756.3697	792.407	876.1191	831.3818	836.9833	845.1866	823.9381
Equity return differentials									
SC (level)	42.1531 (.3472)	25.2103 (.9671)	40.2538 (.459)	30.503 (.8607)	56.6962 (.0419)	27.4858 (.9335)	28.4561 (.9138)	49.3409 (.1478)	49.3409 (.1478)
SC (Sqd.)	34.7234 (.7063)	37.0056 (.6058)	37.4972 (.5835)	51.1854 (.1107)	29.5613 (.8871)	31.0652 (.8424)	42.7774 (.3528)	39.3085 (.5012)	39.3085 (.5012)
Real exchange rate changes									
SC (level)	31.8823 (.8592)	34.3404 (.7011)	42.2779 (.3729)	50.4706 (.1241)	39.2209 (.5052)	40.7816 (.4359)	44.8801 (.2747)	43.3553 (.3302)	46.1687 (.2324)
SC (Sqd.)	15.4039 (.9998)	37.6622 (.5657)	28.917 (.903)	45.3587 (.2491)	27.4809 (.9336)	10.8597 (.7633)	33.1664 (.7694)	17.7511 (.9991)	38.695 (.529)

Note: These parameter estimates are based on DCC-GARCH model: $h_{it} = \vartheta_i + \gamma_{i1}\varepsilon^2_{it-1} + \delta_{i1}h_{it-1}$ and $Q_t = (1-\varphi_1-\omega_1)\bar{Q} + \varphi_1(\varepsilon_{t-1}\varepsilon'_{t-1}) + \omega_1 Q_{t-1}$. SC refers to serial correlation of residuals at level and at square form. *p*-values are in the parentheses.

type modelling appropriate. This study uses the dynamic conditional correlation specification of bivariate GARCH proposed by Engle (2002) to estimate the nexus between the equity return differentials and the real exchange rate changes. The advantages of this approach are the exposition to the direct interdependence between the variables, the adjustment to heteroscedasticity through the standardized residual estimation (Chiang, Jeon, & Li, 2007), and the adjustment of correlation with the time-varying volatility which avoids the volatility bias (J. H. Cho & Parhizgari, 2008; Forbes & Rigobon, 2002).

Let $x_t = [x_{1t,}x_{2t,}]'$ be a 2×1 vector comprising stock return differentials and real exchange rate in a conditional mean equation as[16]:

$$x_t = \mu + \varepsilon_t \text{ and } \varepsilon_t \mid E_{t-1} \sim (0, H_t\ ), \tag{1}$$

where μ is a 2×1 vector of intercept and $\varepsilon_t = [\varepsilon_{1t}, \varepsilon_{2t}]$ is a vector of residuals conditional on the information at time $t-1(E_{t-1})$. The error term is supposed conditionally multivariate normal with mean zero and variance–covariance matrix as follows: $H_t = D_t R_t D_t$, where $D_t = diag\{\sqrt{h_{it}}\}$ is a 2×2 diagonal matrix with time-varying standard deviation from the univariate GARCH models and $R_t = \rho_{ijt}$ for $i, j = 1$, and 2, is a conditional correlation matrix. D_t component follows the univariate GARCH (1, 1) process expressed as:

$$h_{it} = \varphi_i + \gamma_i \varepsilon_{it-1}^2 + \delta_i h_{it-1}\ \forall i = 1, 2. \tag{2}$$

where φ_i is an intercept term, γ_i measures the conditional volatility and δ_i captures the persistence of volatility. The DCC model evolves as:

$$Q_t = (1 - \varphi_1 - \omega_1)\bar{Q} + \varphi_1(\varepsilon_{t-1}\varepsilon_{t-1}') + \omega_1 Q_{t-1}, \tag{3}$$

where $Q_t = q_{ijt}$ is 2×2 is a conditional variance–covariance matrix of standardized residuals, $\bar{Q}$ is an unconditional correlation of $\varepsilon_t\varepsilon_t'$ found through Equation (2), φ_1 and ω_1 are positive scalar parameters fulfilling $\varphi_1 + \omega_1 < 1$. As Q_t in Equation (3) lacks unit elements on diagonal, it's scaled to get the proper correlation matrix R_t as $R_t = diagQ_t^{1/2} Q_t diagQ_t^{-1/2}$. For this research, the interest is in R_t which is $\rho_{ij,t} = q_{ij,t}/\sqrt{q_{ii,t}\, q_{jj,t}}$, $ij = 1,2$ and $i \neq j$ and expresses the DCC between stock return differentials and real exchange rate changes.

4.1.1 | Empirical results - Currency and equity markets nexus

We estimate the DCC between the equity return differentials and real exchange rate changes. Due to the absence of normality in the data series, we use a quasi-maximum likelihood procedure to generate the standard errors that are robust to the non-normality issue. Through the use of alternative lags, data behaviour seems to be appropriately captured by DCC (1, 1) along with each conditional variance in the GARCH (1, 1) process. The sum of γ_i and δ_i is close to one which supports the persistence of GARCH processes for both equity return differentials and real exchange rate changes in most of the sample economies (see Table 2). Similarly, the DCC parameters (i.e., $\varphi_1$and ω_1) are also consistent with the GARCH process. The validity of the models is gauged further through the diagnostic statistics. According to the Ljung-Box-Pierce Q, there is no serial dependence at both level and square of residuals in most of the cases. These results provide support for the suitability of the GARCH model for our study. Next, we discuss the DCC results by plotting the relations between equity return differentials and exchange rate changes.

The DCC graphs for all the nine sample economies are shown in Figure 1. The following observations can be made. First of all, the DCCs for the overall sample show the relationship between the two variables is negative for all the countries except for China.[17] The meaning of the negative relationship for this study is such that the exchange rate depreciation of the domestic currency, say the Malaysian Ringgit, and an increase in the real exchange rate is associated with an equity price decrease.[18] Though our sample of countries and time-period are different than those of Malliaropulos (1998) and Moore and Wang (2014), our results are in agreement with theirs. This may confirm the peculiar feature of emerging markets to award high equity premiums to attract international investors to invest in the stock market (Madhur, 2008). Therefore, a capital account effect emerges as postulated by Branson (1981) and Frankel (1983) in the form of the portfolio-oriented model. These results also signify the rising role of equity markets in our sample of emerging economies. Secondly, the correlation is highly variable for some of the economies, such as India, Indonesia, Korea, and Singapore, which reflects the high volatility of the financial markets.

Thirdly, during the GFC the correlation goes down in some cases (e.g., Singapore, India, Indonesia, etc.) and then comes back again. This is in line with the findings of previous studies where the linkages between the financial markets were found to be intensified during crisis periods and then moving quickly to their normal level after the crisis (Filipe, 2012; Phylaktis & Ravazzolo, 2005). Moreover, during the sub-prime crisis period, a decline in the negative DCCs is supportive of capital flight, and in line with J.-W. Cho et al.'s (2016) study, which points out that capital flows from the emerging markets to the advanced markets during the crisis period is due to the flight-to-quality phenomenon. This implies that during the crisis episode, international investors sell their emerging markets assets (as they are considered riskier than those of advanced markets), which result in less demand for the emerging markets currencies leading to a currency depreciation along with a decrease in the stock prices owning to selling pressure.

5 | ECONOMIC INTEGRATION AND THE STOCK AND FOREIGN EXCHANGE MARKETS NEXUS

Having estimated the DCC between currency and equity markets for each country, we proceed to examine the extent to which economic integration impacts that relationship by estimating the following model:

$$\rho_{i,t} = \gamma_{i,o} + \gamma_{1,i}DM_t + \gamma_{2,i}BT_{i,t} + \gamma_{3,i}ID_{i,t} + \gamma_{4,i}EA_{i,t} + \gamma_{5,i}FD_{i,t} + \mu_{i,t}, \tag{4}$$

where ρ_t stands for the DCC between equity return differentials and the real exchange-rate changes for each country i, BT_t is the ratio of balance of trade to GDP[19] and proxies for real integration, ID_t is real interest rate differential and proxies for financial integration. We use two control variables, economic activity (EA_t) and financial development (FD_t). We introduce a dummy, DM to capture the GFC effect.[20] DM takes the value of one over the period from October-2007 to March-2009 and zero otherwise.

All explanatory variables are taken in logarithmic form except interest rates. More explanation for each variable is given below. Details of the definitions and sources are also given in Table A1.

BT proxies for real integration. The purpose of real integration is to facilitate the flow of trade between the economies and reduce costs, thus, making prices competitive for both traders and consumers. There are various measures of real integration. Traditionally, real integration has conceptually been considered the extent to which international barriers and other restrictions impede international trade of goods (Eatwell, Milgate, & Newman, 1987). However, there is an issue with trade barriers as non-tariff barriers cannot be easily measured (Ammer & Mei, 1996). Trade openness is another measure, where the ratio of exports and imports to GDP is used. However, this measure does not say anything about the level of trade in the absence of trade barriers. This study uses the balance of trade ratio, which is exports minus imports divided by GDP to gauge real integration. This variable captures the openness of an economy and its significant influence will establish the effect of real integration on the currency and equity markets nexus.

ID proxies for financial integration. Financial integration is the process that connects the financial markets of different economies with each other. There are two types of measures of financial integration; *de jure* financial integration and *de facto* financial integration. The former is based on the actual restrictions and regulations submitted by national governments to the International Monetary Fund, which is published in its Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER), which provides a written description of current regulations used for each country as a base to assign the zero–one dummy variable of the presence or absence of restrictions on the current and capital accounts. Zero if the restriction is in place and 1 otherwise. There are two main disadvantages with the *de jure* measures as they do not capture the degree of enforcement and also do not cover regulations that act as capital restrictions but are not counted as such for example, prudential regulations that limit the foreign exposure of domestic banks.

The *de facto* financial integration relates to what is happening based on either the quantities, or the prices of assets. If it is based on the quantities, then actual international capital flows are often used as a measure of financial openness. A common proxy used for this measure is the international assets and liabilities position as a fraction of GDP. If the ratio is high, it implies that an economy is financially open to the rest of the world (Lane and Milesi-Ferretti (2003, 2017)). However, these measures are not available at a monthly frequency, thus, making them inappropriate for our study.

If *de facto* financial integration is based on the prices of assets, markets are said to be "integrated" in the global capital markets if assets with the same attributes command the same expected return irrespective of where they are domiciled. In the absence of financial market impediments, this will lead to equalisation of prices in different markets (De Brouwer, 2005). In our study, we use this measure as a proxy for financial integration, which is provided at a monthly frequency. More precisely, we use real interest rate differential, or otherwise referred to as the real interest rate parity (RIP). RIP is a testable implication of financial integration that avoids the explicit use of exchange rate data by assuming that the (change in) the real exchange rate is constant (the relative purchasing power parity hypothesis holds).[21,22] As emphasized in Chinn and Frankel (1995), Phylaktis (1999), and Obstfeld and Taylor (2003), the RIP hypothesis is also very important because it is based on the existence of frictionless markets. It follows then that a test of the real interest rate differential can tell us the degree of market integration of the particular market.

The real interest rate differential is calculated as the difference between the real interest rate of country *i* and that of the US. Normally, interest rate differentials move towards convergence and synchronization across economies with an increase in financial integration. However, even with financial integration, the interest rate differentials exist due to disparities in the economic factors across the economies.

EA stands for the economic activity of each country and indicates the economic outlook, which determines the overall price level of goods and services including currency and stocks in an economy. It triggers a great influence informing the investor's sentiment related to portfolio rebalancing (Fernández-Amador, Gächter, Larch, & Peter, 2013). This study uses the industrial production index as a proxy for economic activity, which is available at monthly frequency.

FD stands for financial development for each country. Financial development impacts the whole economy including the exchange rate and stock markets (Levine, 1997). Financially developed economies have a better allocation of resources, and therefore, are more competitive and efficient compared to the less developed economies. As explained earlier, Hau and Rey (2006) found that there is a positive relationship between financial development and the correlation between the stock and FX markets. To capture the impact of financial development, this study derives a principal component of three ratios: credit to private sector-to-GDP (*DC*), market capitalization-to-GDP (*MC*), and M3[23]-to-GDP (*MB*). These ratios have been used extensively in the literature to capture financial development (e.g., Hau & Rey, 2006). In the current study, principal component one (PC1) explains the highest proportion of the given three factors (see Table A2), therefore $FD_{i,\,t}$ for economy *i* at time *t* is taken as an aggregate of the products of the relevant proportions and factors values as follows; $FD_{i,t}=\hat{\Gamma}_{1,i}MC_{i,t}+\hat{\Gamma}_{2,i}MB_{i,t}+\hat{\Gamma}_{3,i}DC_{i,t}$; $\hat{\Gamma}_1, \hat{\Gamma}_2, and\ \hat{\Gamma}_3$ are the explained proportions by PC1 for *MC*, *MB*, and *DC*, respectively.

5.1 | Linear autoregressive distributed lag modelling (ARDL)

According to the unit root analysis of the variables in Equation (4), the results show that variables are of a mixed order (i.e., a mix of level stationary I(0) and first differenced stationary I(1) variables). For example, ρ, *BT*, and *EA* are stationary in level, while *ID* and *FD* are stationary in the first difference in the case of India (Table A3).

As a result, this study uses the Autoregressive Distributed Lag Modelling (ARDL) to estimate Equation (4), which accommodates variables of mixed order of integration. Another important advantage of the ARDL model is the simultaneous estimation of the short-run and the long-run estimates in a single equation.[24] The error correction specification of model 4 is as follows in the form of Equation (5):

$$\begin{aligned}\Delta\rho_{i,t}=&\ \eta_{i,o}+\eta_{1,i}DM_t+\sum_{k=1}^{n1}\eta_{2,k}\Delta\rho_{i,t-k}+\sum_{k=0}^{n2}\eta_{3,k}\Delta BT_{i,t-k}\\&+\sum_{k=0}^{n3}\eta_{4,k}\Delta ID_{i,t-k}+\sum_{k=0}^{n4}\eta_{5,k}\Delta EA_{i,t-k}\\&+\sum_{k=0}^{n5}\eta_{6,k}\Delta FD_{i,t-k}+\lambda_o\rho_{i,t-1}+\lambda_1BT_{i,t-1}+\lambda_2ID_{i,t-1}\\&+\lambda_3EA_{i,t-1}+\lambda_4FD_{i,t-1}+\mu_{i,t}.\end{aligned}\tag{5}$$

Specification 5 follows the Pesaran, Shin, and Smith (2001) ARDL framework. The null hypothesis (H_0) of no cointegration against the alternative hypothesis (H_1) for model 5 can be elaborated as:

$$\begin{aligned}&F_\rho((\rho)BT,ID,EA,FD)\\&H_o:\frac{\lambda_1}{\lambda_o}=\frac{\lambda_2}{\lambda_o}=\frac{\lambda_3}{\lambda_o}=\frac{\lambda_4}{\lambda_o}=0\ \text{ and }\ H_1:\frac{\lambda_1}{\lambda_o}\neq\frac{\lambda_2}{\lambda_o}\neq\frac{\lambda_3}{\lambda_o}\neq\frac{\lambda_4}{\lambda_o}\neq0.\end{aligned}\tag{6}$$

Pesaran et al. (2001) recommend that to test for cointegration, one should test the joint significance of the lagged level variables via the F-test, or the Wald test. They also provide critical values to test the presence of cointegration. Each critical value contains a set of two bounds called the lower bound I(0) and the upper bound I(1).[25] The criterion for establishing cointegration is such that the estimated F-statistic should be higher than the upper bound critical value. If the calculated value is lower than the upper critical value, the null hypothesis is accepted. In the case when the calculated value is in between the I(0) and the I(1), the decision is inconclusive. In such cases, there is another alternative approach to test the H_0, namely the error correction term (ECM_{t-1}). This term replaces the lagged level variables in Equation (5). This replacement is done through the normalization as follows[26]:

$$ECM_{t-1}=\rho_{t-1}-\frac{\lambda_1}{\lambda_o}BT_{t-1}-\frac{\lambda_2}{\lambda_o}ID_{t-1}-\frac{\lambda_3}{\lambda_o}EA_{t-1}-\frac{\lambda_4}{\lambda_o}FD_{t-1}.\tag{7}$$

Kremers, Ericsson, and Dolado (1992) conclude that a negative and significant ECM_{t-1} coefficient establishes

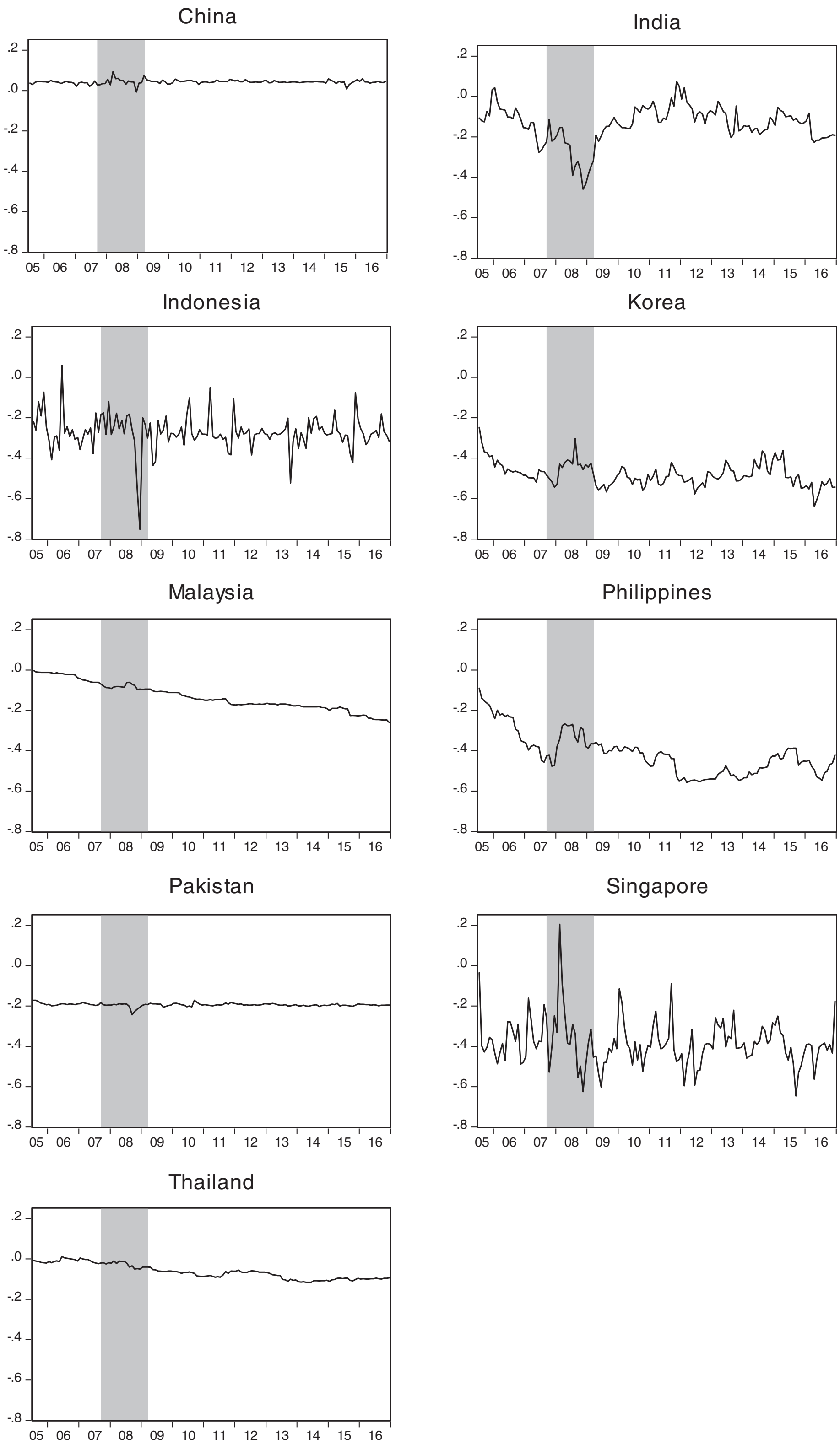

FIGURE 1 Dynamic conditional correlations (DCCs) between currency and equity markets. *Note*: The shaded region denotes the global financial crisis period (October-2007 to March-2009)

the presence of cointegration. However, Pesaran et al. (2001) provide another set of t-ratios to test the significance of the error term called t_{BDM}. If the calculated t-ratio is higher than the upper value of t_{BDM}, H_1 is accepted.

5.1.1 | Empirical results

Table 3, Panel C reports various important diagnostic statistics. The F-statistic, which is the Wald restriction for the presence of cointegration, establishes cointegration in

TABLE 3 Linear ARDL estimates

	China	India	Indonesia	Korea	Malaysia	Pakistan	Philippines	Singapore	Thailand
Panel A: Short run estimates									
ΔBT_t	−0.484 (1.8736)*	−0.3132 (.203)	−2.9379 (.91)	−1.541 (1.2805)	−.13 (1.3058)	−2.28 (2.628)***	.5735 (1.9627)**	.2333 (.2061)	.0258 (.3479)
ΔID_t	.0071 (2.0429)**	0.0039 (.8186)	−0.0006 (.07)	.0205 (1.6472)*	.0006 (.4422)	−.0003 (.5217)	−.0012 (.3228)	.0471 (1.5616)	−.0002 (.1458)
ΔID_{t-1}	.0137 (3.8166)***							.0795 (2.6585)***	
ΔID_{t-2}								−.0746 (2.53)***	
ΔEA_t	−0.0565 (.9405)	.1926 (1.1688)	.254 (.7927)	−.0822 (.7604)	−.011 (.5039)	−.0137 (.6576)	.0504 (1.0874)	.1948 (.943)	−.0168 (1.342)
ΔEA_{t-1}						−.0044 (.1874)			
ΔEA_{t-2}						−.0243 (1.0284)			
ΔEA_{t-3}						.0601 (2.8579)***			
ΔFD_t	.0208 (1.1151)	.0425 (.5989)	−0.21 (1.94)*	−.0869 (.5853)	−.013 (1.072)	−.0059 (.4754)	−.169 (1.4223)	−.7806 (1.7629)*	.0083 (.982)
ΔFD_{t-1}	−.097 (3.1209)***						−.2785 (1.2699)	1.1139 (2.6217)***	
ΔFD_{t-2}							.3064 (2.6552)***		
Panel B: Long run estimates									
Const.	−.0237 (.1805)	1.4764 (.9357)	−0.6882 (1.2332)	−.125 (.1928)	1.5848 (.693)	−.1093 (1.8263)	−2.0734 (1.188)	−1.0782 (1.326)	1.8677 (.5154)
DM_t	.0042 (1.3189)	−.2136 (4.147)***	−.0059 (.2855)	−.0136 (.2872)	.0562 (.5143)	−.0086 (2.832)***	.2858 (1.4323)	.0604 (.8975)	−.1068 (.3363)
BT_t	−.5443 (1.8705)*	−1.2774 (.2037)	−2.4423 (.9001)	−12.89 (2.1965)**	−7.8342 (.595)	−3.442 (2.650)***	9.9594 (1.2359)	.4478 (.2081)	1.5997 (.2289)
ID_t	−.0008 (.1184)	.0158 (1.0639)	−.0005 (.0696)	−.0229 (.801)	.0403 (.3173)	−.0005 (.5205)	−.021 (.2933)	.0097 (.1206)	−.0129 (.154)
EA_t	.0304 (.4641)	−.7509 (1.0639)	.2111 (.8062)	−.2763 (.8048)	−.5986 (.5199)	−.0454 (1.6043)	.8746 (1.0225)	.3739 (.9441)	−1.0369 (.478)
FD_t	.0138 (1.8812)*	.1732 (.5831)	−.1781 (2.0159)**	.4257 (2.4675)***	−.7717 (.8944)	−.0088 (.4712)	−.0933 (.2547)	−.1808 (1.0603)	.516 (.3335)
Panel C: Diagnostic statistics									
F-stat	5.9727	3.7483	8.8795	4.9337	0.8749	7.8949	2.1891	3.3253	0.6223
ECM_{t-1}	−.8902 (6.1318)	−.2452 (4.3898)	−1.2029 (7.2366)	−.2976 (4.1444)	−.2169 (5.761)	−.6636 (7.3771)	−.4176 (4.7874)	−.5211 (4.3659)	−.0161 (6.4449)
Adj. R2	0.2663	0.7895	0.0382	0.5638	0.9929	0.4292	0.9325	0.2828	0.9723
LM	0.1219	0.3961	1.5416	0.0085	0.0581	3.522	1.1084	0.8239	0.2544
RESET	2.6271	0.3465	0.4687	0.1788	0.1092	2.6185	0.0057	2.583	0.0016
CU	S	S	S	S	S	S	S	S	S
CUQ	U	S	S	S	U	U	U	S	S

Note: This table reports short run and long run linear ARDL estimates in the Panels A and B, respectively. ***, **. * show the level of significance at 1, 5, and 10% respectively. The critical values of standard t-distribution, that is, 2.32, 1.96, and 1.64, respectively. The values in the parentheses report t-statistics in absolute form.

Panel C shows the model diagnostic statistics. F-statistic is the Wald restriction which tests the presence of co-integration. At 10% level of significant, its upper critical value is 3.52 (Pesaran et al., 2001, Table CI case iii, pp. 300)). ECM_{t-1} is error correction term and shows the speed of adjustment to the equilibrium. The t-ratio values are reported in the absolute form within the parentheses next to ECMt-1 in their absolute form. The critical value for the t-ratio (t_{BDM}) is −.3.66 at 10% significance level (Pesaran et al., 2001, Table CII case iii, pp.303). LM is Breusch-Godfrey Lagrange Multiplier test of residual serial correlation. RESET is Ramsey's test for model functional form. Both LM and RESET are based on chi-square distribution with critical value of 3.8415 with one degree of freedom at 5% level of significance. CU and CUQ are CUSUM and CUSUMQ, respectively, to test all coefficients stability. S and U denotes stable, and unstable, respectively.

TABLE 4 Nonlinear ARDL estimates

	China	India	Indonesia	Korea	Malaysia	Pakistan	Philippines	Singapore	Thailand
Panel A: Short run nonlinear estimates									
ΔBT_t^+	−.3127 (1.1119)	.5871 (.4076)	−5.3339 (1.1067)	−3.308 (2.025)**	−.0312 (.1622)	−6.047 (3.98)***	.5405 (1.6434)*	.346 (.2659)	−.1402 (1.64)*
ΔBT_{t-1}^+					−.5873 (3.31)***				
ΔBT_{t-2}^+									
ΔBT_{t-3}^+									
ΔBT_t^-	−.4947 (1.7917)*	−.2.4909 (1.465)	−11.09 (2.63)***	1.8244 (1.1053)	−.2082 (1.1452)	−.3788 (.2872)	1.2556 (2.5226)***	1.2732 (1.0859)	.0021 (.0233)
ΔBT_{t-1}^-					.58 (2.8798)***				
ΔBT_{t-2}^-									
ΔBT_{t-3}^-									
ΔID_t^+	.003 (.7108)	.0083 (.9001)	−.0628 (2.263)**	.0128 (.7889)	.0014 (.541)	.0013 (.2097)	−.0049 (.4482)	.0647 (1.7222)*	−.0009 (.5701)
ΔID_{t-1}^+	.0232 (3.4836)***			.019 (.4719)	−.012 (2.781)***		.0099 (.6706)		
ΔID_{t-2}^+				−.0856 (2.562)***			.0288 (1.9619)**		
ΔID_{t-3}^+							−.0446(3.7903)***		
ΔID_t^-	.0366 (5.1036)***	−.0127 (1.3591)	−.0216 (1.6873)*	−.0724 (1.8542)*	−.0071 (1.4114)	−.0059 (2.55)***	.0029 (.4663)	−.0452 (.7219)	.0027 (1.4469)
ΔID_{t-1}^-	.0115 (2.369)***			−.1206 (2.965)***		−.0005 (.1636)		.2344 (4.2151)***	
ΔID_{t-2}^-				−.0025 (.1035)		.0062 (2.1556)**		−.1025 (1.7039)*	
ΔID_{t-3}^-				.0351(1.9158)**		−.0062(2.558)**		.0849(1.6744)*	
ΔEA_t^+	−.0797 (1.2374)	.0539 (.2984)	1.0452 (1.4503)	.4874(1.8843)*	.0825 (1.6798)*	.0309 (1.7628)*	−.1982 (1.1925)	.2045 (.8481)	−.0129 (.8261)
ΔEA_{t-1}^+					−.0538(1.195)				
ΔEA_{t-2}^+					.0089 (.2088)				
ΔEA_{t-3}^+					.0842 (2.2039)**				
ΔEA_t^-	−.0839 (1.3083)	.5288 (2.1429)**	−.3841 (.4887)	.8448 (2.0186)**	−.0121 (.2431)	.0361 (2.023)**	−.1369 (1.7931)*	.1276 (.3935)	−.0196 (1.043)
ΔEA_{t-1}^-			−1.0519 (1.1401)						
ΔEA_{t-2}^-			−1.516 (1.6499)*						
ΔEA_{t-3}^-			1.3937 (1.8575)*						
ΔFD_t^+	−.0004 (.019)	−.1989 (.6948)	−.1037 (.8198)	.2528 (1.3415)	−.0132 (.5866)	−.0046 (.4677)	−.1236 (1.7108)*	.0099 (.0602)	.0029 (.3229)
ΔFD_{t-1}^+	−.05144 (2.252)**			−.0998 (.2913)					
ΔFD_{t-2}^+				−.927 (2.8599)***					
ΔFD_{t-3}^+				.7251 (3.8057)***					
ΔFD_t^-	.0385 (1.2698)	.5609 (.9121)	−.0689 (.2092)	−.2465 (1.7852)*	−.0879 (1.983)**	.1337 (1.6053)	−.4428 (1.1735)	−2.0655 (1.1792)	−.08 (2.71)***
ΔFD_{t-1}^-		1.1824 (1.85)*						−1.4205 (.6172)	
ΔFD_{t-2}^-								1.5784 (.7023)	
ΔFD_{t-3}^-								3.7893 (2.3737)***	

TABLE 4 (Continued)

	China	India	Indonesia	Korea	Malaysia	Pakistan	Philippines	Singapore	Thailand
Panel B: Nonlinear long run estimates									
Const.	.044 (12.758)***	−.0007 (.0133)	−.0919(1.74)*	−.51 (9.34)***	−.0051 (.4239)	−.19 (61.8)***	−.41 (2.031)**	−.364 (4.41)***	−.0219 (1.962)**
DM	.0047 (1.0805)	−.219 (2.85)***	.0307 (1.2972)	−.0751 (.753)	.0081 (.6067)	−.008 (3.1)***	.5861 (1.558)	−.0629 (.7953)	.0277 (2.8309)***
BT_t^+	−.3114 (1.088)	2.0261 (.407)	−3.75 (1.1248)	−9.941 (1.78)*	−1.36 (1.648)*	−3.01 (2.24)**	6.4013 (1.14)	.5102 (.2653)	−.7232 (1.777)*
BT_t^-	−.4928 (1.80)*	−8.595 (1.483)	−7.8 (2.68)***	−6.6289 (1.38)	−1.785 (1.81)*	−3.6 (2.44)***	14.87 (1.0112)	1.8771 (1.0922)	.0107 (.0233)
ID_t^+	.0016 (.3916)	.0288 (.9076)	−.0442 (2.2)**	.0469 (1.045)	.023 (1.700)*	.0002 (.2097)	14.87 (1.220)	−.0723 (1.122)	−.0047 (.5625)
ID_t^-	−.0002 (.070)	−.043 (1.267)	−.015 (1.68)*	−.0041 (.102)	.031 (1.99)**	.0005 (.3208)	.0345 (.5416)	−.0515 (.8524)	.0138 (1.5297)
EA_t^+	−.0794 (1.23)	.1859 (.307)	.7351 (1.48)	1.46 (1.63)*	−.1538 (.584)	.038 (1.84)*	.898 (.7149)	.3016 (.8673)	−.0667 (.779)
EA_t^-	−.0835 (1.268)	1.82 (2.198)**	1.61 (2.73)***	2.539 (2.16)**	.5635 (1.872)*	.0451 (2.08)**	−1.6212 (1.13)	.1882 (.3926)	−.1012 (.9908)
FD_t^+	.0054 (.4461)	−.686 (.7019)	−.0729 (.823)	−.0443 (.154)	.096 (2.02)**	−.0057 (.4681)	1.464 (1.2178)	.0147 (.0602)	.0152 (.3087)
FD_t^-	.0384 (1.3044)	.3264 (.3122)	−.0485 (.2098)	−.7408 (1.66)*	−.474 (2.12)**	.0175 (.4067)	5.2448 (.8458)	−.9579 (.6485)	.4134 (2.8388)***
Panel C: Nonlinear model diagnostic statistics									
F-stat	7.773	3.8458	6.0965	4.0378	2.9316	6.8753	2.9164	4.5753	3.0739
ECM_{t-1}	−1.0039 (8.2371)	−.2898 (4.6196)	−1.4218 (8.2004)	−.3327 (4.5965)	−.1855 (5.6959)	−.8005 (7.6223)	−.4844 (7.6493)	−.6783 (6.0618)	−.1939 (8.4049)
Adj. R2	0.2906	0.8038	0.1234	0.6082	0.9942	0.4792	0.9329	0.3373	0.9745
LM	0.1824	0.1775	0.4214	0.6788	0.0864	3.7049	0.4537	2.5128	0.7129
RESET	2.3482	3.3596	0.4098	2.4508	0.0058	3.6124	0.0849	2.5221	2.0015
CU	S	S	S	S	S	S	U	S	S
CUQ	S	S	U	S	S	U	S	S	S

Note: This table reports nonlinear ARDL short run and long run estimates in panels A and B, respectively. ***, **. * show the level of significance at 1, 5, and 10% respectively. The critical values of standard t-distribution, that is, 2.32, 1.96, and 1.64. are used respectively. The values in the parentheses report t-statistics in absolute form.

Panel C shows the model diagnostic statistics. F-statistic is the Wald restriction which tests the presence of co-integration. At 10% level of significance, its critical value is 3.52 (Pesaran et al., 2001, Table CI case iii, p. 300)). ECMt-1 is error correction term and shows the speed of adjustment to the equilibrium). The t-ratio values are reported in absolute form within the parentheses next to ECMt-1. The critical value for the t-ratio is −.4.40 at 10% significance level (Pesaran et al., 2001, Table CII case iii, pp. 303). LM is Breusch-Godfrey Lagrange Multiplier test of residual serial correlation. RESET is Ramsey's test for model functional form. Both LM and RESET are based on chi-square distribution with critical value of 3.8415 with one degree of freedom at 5% level of significance. CU and CUQ are CUSUM and CUSUMQ, respectively, to test all coefficients stability. S and U denotes stable, and unstable, respectively.

TABLE 5 Asymmetric statistics

	China	India	Indonesia	Korea	Malaysia	Pakistan	Philippines	Singapore	Thailand
Panel A. Wald test for short-run asymmetry (WSR)									
ΔBT_t	.0466 (.8295)	.7517 (.3877)	.8003 (.3729)	2.1756 (.1432)	7.8936 (.0059)***	.4449 (.5061)	3.2417 (.0745)*	.2325 (.6306)	.408 (.5242)
ΔID_t	.0259 (.8723)	1.9447 (.1658)	.5435 (.4625)	2.3462 (.1286)	.0687(.7937)	14.5973 (.0000)***	10.8768 (.0013)***	.3668 (.546)	.0053 (.942)
ΔEA_t	1.4319 (.234)	.8117 (.3695)	1.2823 (.2599)	2.4098 (.1236)	5.7119 (.0186)***	.9089 (.3425)	.5287 (.4686)	.0064 (.9362)	1.2358 (.2686)
ΔFD_t	5.6912 (.0187)***	.0931 (.7609)	.0118 (.9138)	.0328 (.8565)	.2582 (.6124)	2.6822 (.1043)*	.0002 (.9879)	1.1252 (.2891)	.0454 (.8317)
Panel B. Wald test for long-run asymmetry (WLR)									
BT_t	6.8361 (.0102)***	3.8254 (.0529)**	8.5087 (.0043)***	.0338 (.8544)	.8012 (.3727)	1.664 (.1998)	2.3366 (.1292)	1.0295 (.3126)	2.0446 (.1555)
ID_t	2.0535 (.1547)	1.1799 (.2796)	8.1328 (.0052)***	.0586 (.8091)	1.4612 (.2294)	.5746 (.45)	.2633 (.6089)	2.7174 (.1022)*	7.0714 (.009)***
EA_t	2.1912 (.1416)	2.5807 (.1109)	21.5586 (.0000)***	.0783 (.7801)	11.2569 (.0011)***	.3666 (.5461)	.5922 (.4432)	.2213 (.639)	.0063 (.9369)
FD_t	7.2624 (.0081)***	.2095 (.648)	.1033 (.7485)	.0323 (.8576)	4.7188 (.032)**	.3104 (.5786)	2.4735 (.1186)	1.7884 (.184)	5.0681 (.0263)**

Note: ***, **. * show the level of significance at 1, 5, and 10% respectively. *p*-values are in parentheses.

TABLE 6 Summary of long-run estimates based on linear and nonlinear ARDL

	ARDL									NARDL								
	China	India	Indonesia	Korea	Malaysia	Pakistan	Philippines	Singapore	Thailand	China	India	Indonesia	Korea	Malaysia	Pakistan	Philippines	Singapore	Thailand
BT_t	–			–		–												
BT_t^+													–	–	–			–
BT_t^-										–		–		–	–			
ID_t																		
ID_t^+												–		+				
ID_t^-												–		+				
EA_t																		
EA_t^+													+		+			
EA_t^-											+	+	+	+	+			
FD_t	+		–	+														
FD_t^+														+				
FD_t^-													–	–				+
DM_t		–				–					–				–			+

Note: Summary of results based on Table 3, Panel B and Table 4, Panel B such that statistically significant coefficients signs are reported here.

all the countries apart from Malaysia, the Philippines, Singapore, and Thailand based on the 3.52 critical value provided by Pesaran et al. (2001). In these cases, we apply the error correction term ECM_{t-1}. All the *t*-values for the ECM_{t-1} are above the −3.66 critical value, establishing cointegration for all the countries. Other model statistics are the adjusted R^2, the Breusch-Godfrey Lagrange Multiplier test of residual serial correlation (LM), and Ramsey's test for model functional form (RESET). All the LM and RESET values are insignificant, so, all the models are free of serial correlation and have their right functional form. We test the stability of the models through the use of CUSUM and CUSUMQ denoted by CU and CUQ2 respectively. According to either the CUSUM or the CUSUMQ, all the models are found to be stable. The above diagnostic statistics are supportive of the appropriateness of the adopted model and the meaningfulness of the short-run and the long-run estimates.

Table 3, Panels A and B, report the results for the short and long-run estimates of Equation (5) respectively. Focusing first on the long-run estimates, we note that the coefficient of the trade channel is significant only in the case of China, Korea, and Pakistan and impacts the currency and equity markets nexus. This means that improvements in the trade balance increase equity prices and also improves the domestic currency value. Therefore, when the economy is having a balance of trade surplus, it promotes the negative correlation between the currency and equity markets. This translates into the role of real integration as a conduit for the relationship and supports the trade-based linkage of these economies with the rest of the world. The impact of real integration is also present in the short-run, negative in China and Pakistan and positive in the Philippines.

On the other hand, it is important to note that financial integration, measured by the interest rate differential, does not affect any of the countries in the long-run, so the limited financial integration impact found in the short-run does not carry over to the long-run. It was found in the short-run to be positively significant with varying lags in the case of China, Korea, and Singapore. Thus, similar to Moore and Wang (2014), we could not find any effect of the financial integration channel for Asian economies. However, their research was based on lower data frequency (i.e., quarterly) and for a different period and group of countries. As the financial channel response is fast, we expected to find its influence, if it existed, in our study, which is based on higher frequency data (i.e., monthly) and covers a more recent period, where capital mobility was higher.

In the next section, we extend our analysis to the non-linear framework to explore these findings further.

Looking now at the control variables, we find financial development to have a negative impact in some cases in the short-run, which turns mainly positive in the long-run, supporting Hau and Rey's (2006) finding that correlations between the two markets are higher for countries with higher financial development. Economic activity does not seem to have much of an impact either in the short-run, or the long-run. The coefficient for the dummy variable is significant only in the case of India and Pakistan in the long-run with a negative sign. This means that the financial crisis was associated with a decline in the correlation in these countries. This corroborates the fall in the correlation as shown in Figure 1. However, the lesser GFC effect in the rest of the countries can be due to the fact that the impact of the GFC was not so severe in the Asian economies compared to the advanced economies (Goldstein & Xie, 2009).

5.2 | Nonlinear ARDL (NARDL)

Specification 5 assumes that all the variables affect the relationship between the currency and equity markets symmetrically. This may not be the case where macroeconomic variables show, non-linearity in their behaviour. The relationship between the currency and equity markets may change differently with the changes in the level of economic integration. Whether an increase or a decrease in economic integration have a symmetric or asymmetric effect can be tested through the approach introduced by Shin et al. (2014). Thus, we decompose each explanatory variable into two series, such that one series shows a partial sum of increase and the other series shows a partial sum of decrease. These are structurally constructed as follows for the real integration variable:

$$\begin{aligned} BT_t^+ &= \sum\nolimits_{j=1}^{t} \Delta BT_t^+ = \sum\nolimits_{j=1}^{t} max\left(\Delta BT_j, 0\right), \\ BT_t^- &= \sum\nolimits_{j=1}^{t} \Delta BT_t^- = \sum\nolimits_{j=1}^{t} min\left(\Delta BT_j, 0\right). \end{aligned} \tag{8}$$

We generate in the same way the partial sum for all the other explanatory variables. Substituting these partial sum series in the specification (5) we get the following:

$$\Delta\rho_{i,t} = \eta_{i,o} + \eta_{1,i} DM_t + \sum_{k=1}^{n1} \eta_{2,k} \Delta\rho_{i,t-k} + \sum_{k=0}^{n2} \eta_{3,k} \Delta BT_{i,t-k}^{+} + \sum_{k=0}^{n3} \eta_{4,k} \Delta BT_{i,t-k}^{-} + \sum_{k=0}^{n4} \eta_{5,k} \Delta ID_{i,t-k}^{+} + \sum_{k=0}^{n5} \eta_{6,k} \Delta ID_{i,t-k}^{-}$$

$$+\sum_{k=0}^{n6}\eta_{7,k}\Delta EA^{+}_{i,t-k}+\sum_{k=0}^{n7}\eta_{8,k}\Delta EA^{-}_{i,t-k}+\sum_{k=0}^{n8}\eta_{9,k}\Delta FD^{+}_{i,t-k}$$
$$+\sum_{k=0}^{n9}\eta_{10,k}\Delta FD^{-}_{i,t-k}+\lambda_o\rho_{i,t-1}+\lambda_1 BT^{+}_{i,t-1}+\lambda_2 BT^{-}_{i,t-1}$$
$$+\lambda_3 ID^{+}_{i,t-1}+\lambda_4 ID^{-}_{i,t-1}+\lambda_5 EA^{+}_{i,t-1}+\lambda_6 EA^{-}_{i,t-1}$$
$$+\lambda_7 FD^{+}_{i,t-1}+\lambda_8 FD^{-}_{i,t-1}+\mu_{i,t} \quad . \tag{9}$$

Specification 9 is termed as NARDL by Shin et al. (2014). They show that the linear approach of Pesaran et al. (2001) is equally applicable to their non-linear version. Similar to ARDL, the null hypothesis of no cointegration $\left(\frac{\lambda_1}{\lambda_o}=\frac{\lambda_2}{\lambda_o}=\frac{\lambda_3}{\lambda_o}=\frac{\lambda_4}{\lambda_o}=\frac{\lambda_5}{\lambda_o}=\frac{\lambda_6}{\lambda_o}=\frac{\lambda_7}{\lambda_o}=\frac{\lambda_8}{\lambda_o}=0\right)$ is tested through the F-test or the ECM_{t-1} as detailed in the earlier section. Once cointegration is established, the normalized coefficient of partial sum positive series is tested with counterpart normalized partial sum negative series coefficient (e.g., for real integration λ_1 with λ_2 in case of the long run and η_{3k} with η_{4k}in the case of the short run). If the size, or the sign of the partial sum positive and negative coefficients are not the same, the effect is said to be asymmetric, otherwise, the effect is concluded to be symmetric.

5.2.1 | Empirical results

In this section we investigate the impact of real integration and financial integration on the association between currency and equity markets using a non-linear or asymmetric framework, the non-linear ARDL approach suggested by Shin et al. (2014). Before moving to the non-linear estimates, it is necessary to check first the null hypothesis of no cointegration. If the null hypothesis is rejected, one can proceed to the NARDL approach. Table 4, Panel C reports the cointegration results. Based on the F-test, cointegration is established for all the countries except Malaysia and the Philippines as the critical upper bound value is less than the estimated *F*-values. However, cointegration is established in all the cases based on ECM_{t-1}. Table 4, Panel C reports also a set of other important diagnostic statistics, which show that the functional form of models is appropriate, free of serial correlation, and according to either the CUSUM or the CUSUMQ, stable. The above diagnostic statistics are supportive of the appropriateness of the adopted model and the meaningfulness of the short-run and the long-run estimates.

We then proceed to establish whether there are asymmetric effects. Bahmani-Oskooee, Aftab, and Harvey (2016) suggest that an asymmetric effect can be established by one of the following three ways. First, short-run adjustment asymmetry is established when the partial sum of positive and negative variables come with different lags based on the optimal lag length selection criterion; the short-run asymmetry is established when either the size or the sign of the coefficient of partial sum positive and negative variables is different at each lag; and finally, if the cumulative or impact asymmetry of a variable is established when the sum of partial sum positive variable lags is different from the sum of partial sum negative lags tested by applying the Wald test.

Applying the above criteria to the short-run estimates, we observe the following (see Table 4, Panel A). Adjustment asymmetry of the trade channel is not present, while adjustment asymmetry of interest rate differentials is observed in the case of Korea, Malaysia, Pakistan, the Philippines, and Singapore. On the other hand, short-run asymmetry based on either the magnitude or the sign of the coefficient is observed in all the nine countries. The results for cumulative asymmetry are reported in Table 5, Panel A shows that trade balance asymmetry is observed in the case of Malaysia and the Philippines, and interest rate differentials asymmetry is present in the case of Pakistan and the Philippines. These results support the short-run asymmetric effects of economic integration in defining the association between currency and equity markets. In conclusion, per one or more of the three criteria, we have established the existence of asymmetric effects in the short-run.

Moving to the long-run, we note that cumulative asymmetry for real integration is established in China, India, and Indonesia and for interest rate differentials in Indonesia, Singapore, and Thailand based on the Wald test (Table 5, Panel B). However, long-run asymmetry based on either size, or sign for both real and financial channels is established in all the countries. The asymmetric effects of *EA* are established based on the Wald test in the case of Indonesia and Malaysia; for *FD* in the case of Malaysia and Thailand.

Having established asymmetric effects in both the short-run and the long-run, which render inappropriate the use of linear frameworks applied in previous studies, we proceed to investigate the long-run asymmetric effects (Table 4, Panel B) and compare them to the results of the linear long-run analysis. The effect of BT^{+}_{t} is observed in the case of Korea, Malaysia, Pakistan, and Thailand and the influence of BT^{-}_{t} is present in the case of China, Indonesia, Malaysia, and Pakistan. In the linear analysis, the effect of the balance of trade channel was only observed in the case of China, Korea, and Pakistan. Table 6 summarizes the results of the long-run linear and non-linear estimations. The sign of the effect for Malaysia is the same for the BT_t^+ and BT_t^-, however, the magnitude of the coefficient is different, establishing the asymmetric effect. It is also notable that the magnitude of the coefficient BT_t^- is higher than that of BT_t^+ in other cases. This finding is interesting and may imply that a fall in the real channel has higher influence compared to a surge in it in determining the correlations. This finding is analogous particularly to behavioural finance. For example, the prospect theory by Kahneman and Tversky (1979) proposes that the financial response to losses is higher than that of gains in the financial markets. Similar to this, the determining force of the correlation between the currency and equity markets seems to be triggered more by a decrease in the real channel than an increase. The trade balance coefficient is negative in all the significant cases. This means trade balance is associated with a negative correlation. This implies that a positive trade balance improves equities' performance and appreciates the exchange rate. Therefore, in the case when a country has a trade surplus, the negative correlation between currency and equity markets is further enhanced. Although we are not discussing short-run estimates in detail, it should be noted that the asymmetric effects for the balance of trade are also present in the short-run and are more pronounced than in the linear estimation. This means that separating the trade balance into increases and decreases yields more short-run significant effects.

Similarly, the effect of financial integration is observed in the non-linear model. Both ID_t^+ and ID_t^- have a significant effect in Indonesia and Malaysia, with a positive sign in the case of Malaysia, and a negative sign in the case of Indonesia. In the linear model, the effect was not present in any case. The positive coefficient of interest rate differential implies that improvements in the interest rate differential lead to depreciation in the exchange rate (in line with UIP), which improves the international competitiveness of firms, their profitability and subsequently stock performance in accord with the flow-oriented model, and the Hau and Ray model, (2006) of a positive association between the real exchange rate and the stock price differential for the emerging market. On the other hand, a negative interest rate differential coefficient is associated with a negative time-varying correlation. This means that the surge in the stock prices improves the currency value through the demand for money, and therefore interest rates in support of the portfolio approach and the Malliaropulos (1998) model. Overall, the non-linear analysis reveals more support for financial integration in connecting the currency and equity markets. Asymmetric effects are also present in the short-run (Table 4, Panel A) and are more pronounced than in the linear case. Thus, the non-linear adjustments show more support for the financial channel on the currency equity markets nexus, compared to the linear case.

Regarding the control variables, we note asymmetric effects in both *FD* and *EA* in many countries in both the short-run and the long-run, while in the linear case *EA* did not have an impact either in the short-run or the long-run.

In summary, the results of the non-linear approach show that both real integration and financial integration explain financial market linkages. We find this approach is more appropriate than the linear approach as the linearity assumption is shown not to hold.

6 | CONCLUSION

In this study, we investigate the dynamic relationship between the equity return differentials and real exchange rate changes for a group of Asian emerging markets over the period 2005–2016, by estimating first, the dynamic conditional correlations, and then examining the impact of economic integration, both real and financial integration on that relationship. Our sample consists of nine countries, which includes both China and India, which play an important role globally and regionally in terms of the size of their economies, trade, and capital flows.

The conditional correlation analysis shows that there is a negative correlation between real exchange rate changes and equity return differentials in all the countries apart from China, which becomes deeper for some of them during the GFC. Most importantly we find that economic integration, both real and financial, has an asymmetric impact on the relationship between the two markets both in the short-run and in the long-run. Applying a linear framework does not bring out the impact of financial integration. Besides, only some effects of real integration carry over to the long-run. However, we find that the linear assumption does not hold and that explains the results of previous studies, which rely on linear models and report that financial integration does not impact the currency equity markets nexus (e.g., Moore & Wang, 2014). Their inferences are misleading since we have established that non-linearity is present.

The findings of this study imply that it is not a single theory that explains the relationship between the currency and equity markets, rather it is the time-varying nature of the relationship that resonates with a particular theory. Though the study finds that the portfolio-oriented model and the Malliaropulos model predominantly explain the relationship, there is also some support for the goods market channel and the Hau and Rey model over time. This translates into the importance of a time-varying approach to study the relationship.

From the investors' point of view, a sound understanding of the currency-equity markets linkages can help to formulate effective investment decisions regarding hedging arrangements and overall portfolio performance. The findings pinpoint that the fall in stock market performance is associated with real exchange rate depreciation. Therefore, the total return for an international equity investor, which is the sum of her equity investment return and exchange rate changes requires some hedging arrangement. Therefore, a portfolio strategy that hedges currency risk may beat a strategy that keeps the currency risk uncovered. Similarly, a global asset allocation strategy in Asian emerging equity markets may take a long position if the judgement is based on information that there is currency appreciation.

The study highlights the time-varying relationship of the currency and equity markets, and the asymmetric impact of economic integration. The analysis implies that the current climate of reverse economic integration, with the building up of trade tariff tensions, otherwise referred to as "deglobalization" will certainly have an impact on the two markets with repercussions for governments and investors.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from [third party]. Restrictions apply to the availability of these data, which were used under license for this study. Data are available [from the authors with the permission of [third party].

ORCID

Kate Phylaktis https://orcid.org/0000-0001-9392-1682

ENDNOTES

[1] For instance, Malaysia and China abandoned their fixed exchange rate regimes in July 2005. Ilzetzki, Reinhart, and Rogoff (2019) provide a comprehensive global exchange rates arrangements outlook.

[2] The valuation changes due to the variation in currency and equity returns generate valuation swings in international investment positions and the subprime crisis was particularly subject to these swings (Cenedese, Payne, Sarno, & Valente, 2015).

[3] Ülkü and Demirci (2012) provide support for this proposition. Using structural vector autoregression, they examine the linkage between the currency and stock markets in the emerging European markets and report a strong relationship in the markets where the co-integration was absent.

[4] For example, Caporale, Hunter, and Ali (2014) examine the time varying currency and equity markets dynamics for the advanced countries using BEKK representation of GARCH., Moore and Wang (2014) use DCC-GARCH for a sample of emerging and advanced markets.

[5] https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?view=chart.

[6] The assumption of linearity describes that a 2% increase in an independent variable has twice the influence of a 1% increase in an independent variable on the dependent variable; and an effect of the same magnitude on the dependent variable for a decrease in the independent variable with an opposite sign (Bussiere, 2013).

[7] Nominal exchange rate is defined as domestic currency per unit of foreign currency. In this example, the Malaysian Ringgit is the domestic currency.

[8] The real exchange rate is defined as nominal exchange rate times the foreign goods prices relative to domestic goods prices.

[9] The stock price differential is defined as the difference between the equity market return of the domestic economy and the US equity market returns. Throughout the paper, we will be using Malaysia as an example of the domestic economy.

[10] Foreign trade ratio is calculated by summing up the exports and imports divided them by GDP.

[11] European Commission (EC) 2013.

[12] https://www.msci.com/documents/1296102/1330218/MSCI_Market_Classification_Framework.pdf/d93e536f-cee1-4e12-9b69-ec3886ab8cc8.

[13] China and Malaysia abandoned the fixed exchange rate regime on July 21, 2005. For the sake of comparison, we keep the starting date same for all the sample economies.

[14] The data that support the findings of this study are available from [third party]. Restrictions apply to the availability of these data, which were used under license for this study. Data are available [from the authors with the permission of [third party].

[15] This may be due to managed exchange rate regimes in the emerging economies.

[16] This draws from Moore and Wang's (2014) exposition.

[17] This might be due to excessive interference by the Chinese authorities in their currency market to keep the currency undervalued. In this way, exchange rate depreciation enhances exports through the improvement in the international competitiveness, which improves country fundamentals and therefore the corporate value of a firm in the form of stock price rises. Another way, this finding tells that a stimulus in the equity market can be injected through the improvements in the international competitiveness that decreases exports prices and increases a firm's profitability. This can serve as an alternative in a well-developed and a reasonable sized equity market. This result is supportive to the flow-oriented model postulated by Dornbusch and Fischer (1980). This finding is very relevant to emerging economies in times of economic slowdown as their focus is more export-oriented (Kokko, 2006).

[18] This transcription of the relationship is due to the fact that exchange rate is defined as domestic currency per unit of foreign currency. So, an increase in the exchange rate implies a decrease in the value of the domestic currency value, in our example the Malaysian Ringgit and an increase in the real exchange rate.

[19] As GDP is available quarterly, we converted it to monthly frequency through the linear interpolation using EXPAND procedure in SAS software. Compared to other methods, linear interpolation preserves the data properties like mean, sum (Tiwari, 2014).

[20] The crisis episodes can influence the currency and equity markets linkages (Caporale et al., 2014).

[21] For a derivation of the RIP, see Phylaktis (1999).

[22] There is evidence, albeit for a different time period that indeed the real exchange rate is stationary for the Pacific Basin countries (Phylaktis & Kassimatis, 1994).

[23] Monetary base is taken as M2 for China, India, Indonesia, Korea and Pakistan.

[24] Single step error correction modelling is more efficient than that of the two steps modelling (Shin et al., 2014).

[25] Narayan (2005) provides the critical values for small samples.

[26] Bahmani-Oskooee and Tankui (2008) provide the details of normalization procedure.

REFERENCES

Ammer, J., & Mei, J. (1996). Measuring international economic linkages with stock market data. *The Journal of Finance*, *51*(5), 1743–1763.

Bahmani-Oskooee, M., Aftab, M., & Harvey, H. (2016). Asymmetry cointegration and the J-curve: New evidence from Malaysia-Singapore commodity trade. *The Journal of Economic Asymmetries*, *14*, 211–226.

Bahmani-Oskooee, M., & Fariditavana, H. (2015). Nonlinear ARDL approach, asymmetric effects and the J-curve. *Journal of Economic Studies*, *42*(3), 519–530.

Bahmani-Oskooee, M., & Saha, S. (2015). On the relation between stock prices and exchange rates: A review article. *Journal of Economic Studies*, *42*(4), 707–732.

Bahmani-Oskooee, M., & Tankui, A. (2008). The black market exchange rate vs. the official rate in testing PPP: Which rate fosters the adjustment process? *Economics Letters*, *99*(1), 40–43.

Barro, R. J., & Lee, J. W. (Eds.). (2011). *Costs and benefits of economic integration in Asia*. Great Clarendon st., Oxford: Oxford University Press.

Bekaert, G., & Harvey, C. R. (2017). *Emerging equity markets in a globalizing world*. Retrieved from https://ssrn.com/abstract=2344817

Branson, W. H. (1981). *Macroeconomic determinants of real exchange rates* (National Bureau of Economic Research Working Paper Series, No. 801). Retrieved from http://dx.doi.org/10.3386/w0801

Bussiere, M. (2013). Exchange rate pass-through to trade prices: The role of nonlinearities and asymmetries. *Oxford Bulletin of Economics and Statistics*, *75*(5), 731–758.

Bussière, M., Schmidt, J., & Valla, N. (2018). International financial flows in the new normal: Key patterns (and why we should care). L. Ferrara I. Herando & D. Marconi. In *International macroeconomics in the wake of the global financial crisis* (pp. 249–269). Cham, Switzerland: Springer.

Caporale, G. M., Hunter, J., & Ali, F. M. (2014). On the linkages between stock prices and exchange rates: Evidence from the banking crisis of 2007–2010. *International Review of Financial Analysis*, *33*, 87–103.

Cenedese, G., Payne, R., Sarno, L., & Valente, G. (2015). What do stock markets tell us about exchange rates? *Review of Finance*, *20*(3), 1045–1080. https://doi.org/10.1093/rof/rfv032

Chiang, T. C., Jeon, B. N., & Li, H. (2007). Dynamic correlation analysis of financial contagion: Evidence from Asian markets. *Journal of International Money and Finance*, *26*(7), 1206–1228.

Chinn, M. D., & Frankel, J. A. (1995). Who drives real interest rates around the Pacific Rim: The USA or Japan? *Journal of International Money and Finance*, *14*(6), 801–821.

Chkili, W., & Nguyen, D. K. (2014). Exchange rate movements and stock market returns in a regime-switching environment: Evidence for BRICS countries. *Research in International Business and Finance*, *31*, 46–56.

Cho, J. H., & Parhizgari, A. (2008). East Asian financial contagion under DCC-GARCH. *International Journal of Banking and Finance*, *6*(1), 17–20.

Cho, J.-W., Choi, J. H., Kim, T., & Kim, W. (2016). Flight-to-quality and correlation between currency and stock returns. *Journal of Banking & Finance*, *62*, 191–212.

Choudhry, T., & Hassan, S. S. (2015). Exchange rate volatility and UKimports from developing countries: The effect of the global financial crisis. *Journal of International Financial Markets, Institutions and Money*, *39*, 89–101.

Crockett, A. (2002). *Capital flows in Asia since the crisis*. BIS speech on the occasionof the meeting of deputies of the ASEAN plus Three in Beijing, 11th of October 2002.

Dai, Y. (2014). *Business cycle synchronization in Asia: The role of financial and trade linkages* (ADB Working Paper No. 139. October, 2014 Series on Regional Economic Integration).

De Brouwer, G. (2005). Monetary and financial integration in Asia: Empirical evidence and issues. In *Asian economic cooperation and integration: Progress, prospects, and challenges* (p. 269–298). Manila, Philippines: Asian Development Bank.

Dornbusch, R., & Fischer, S. (1980). Exchange rates and the current account. *The American Economic Review*, *70*(5), 960–971.

Driessen, J., & Laeven, L. (2007). International portfolio diversification benefits: Cross-country evidence from a local perspective. *Journal of Banking & Finance*, *31*(6), 1693–1712.

Eatwell, J., Milgate, M., and Newman, P. (1987). *The new Palgrave: A dictionary of economics*. London, UK: Macmillan Publishers.

Engle, R. (2002). Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business & Economic Statistics*, *20*(3), 339–350.

Fernández-Amador, O., Gächter, M., Larch, M., & Peter, G. (2013). Does monetary policy determine stock market liquidity? New evidence from the euro zone. *Journal of Empirical Finance*, *21*, 54–68.

Filipe, S. F. (2012). Equity order flow and exchange rate dynamics. *Journal of Empirical Finance*, *19*(3), 359–381.

Forbes, K. J., & Rigobon, R. (2002). No contagion, only interdependence: Measuring stock market comovements. *The Journal of Finance*, *57*(5), 2223–2261.

Frankel, J. A. (1983). *Monetary and portfolio-balance models of exchange rate determination*. Cambridge, MA: MIT.

Gavin, M. (1989). The stock market and exchange rate dynamics. *Journal of International Money and Finance*, *8*(2), 181–200.

Goldstein, M., & Xie, D. (2009). *The impact of the financial crisis on emerging Asia* (Peterson Institute for International Economics Working Paper, 09-11). Washington DC, October 2011.

Hau, H., & Rey, H. (2006). Exchange rates, equity prices, and capital flows. *Review of Financial Studies*, *19*(1), 273–317.

Ilzetzki, E., Reinhart, C. M., & Rogoff, K. S. (2019). Exchange arrangements entering the 21st century: Which anchor will hold? *The Quarterly Journal of Economics*, *134*(2), 599–646.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, *47*(2), 263–291.

Keynes, J. M. (1936). *The general theory of interest, employment and money*. London, England: Macmillan.

Kokko, A., Soderman, S. (2006). *Export-Led growth in East Asia: Lessons for Europe's transition economies*. Emerging Multiplicity, Palgrave Macmillan, London: Springer.

Kremers, J. J., Ericsson, N. R., & Dolado, J. J. (1992). The power of cointegration tests. *Oxford Bulletin of Economics and Statistics*, *54*(3), 325–348.

Lane, P. R., & Milesi-Ferretti, G. M. (2017). *International financial integration in the aftermath of the Global Financial Crisis* (IMF Working Papers, 17/115), International Monetary Fund.

Lane, P. R., & Milesi-Ferretti, G. M. (2003). International financial integration. *International Monetary Fund Staff Papers*, *50*, 82–113.

Levine, R. (1997). Financial development and economic growth: Views and agenda. *Journal of Economic Literature*, *35*(2), 688–726.

Madhur, S. (2008, February). *Capital market development in emerging East Asia: Issues and challenges*. Paper presented at the 9th OECD-ADBI Roundtable on Capital Market Development in Asia, Tokyo, Japan.

Malliaropulos, D. (1998). International stock return differentials and real exchange rate changes. *Journal of International Money and Finance*, *17*(3), 493–511.

Milesi-Ferretti, G. M., & Tille, C. (2011). The great retrenchment: International capital flows during the global financial crisis. *Economic Policy*, *26*(66), 289–346.

Moore, T., & Wang, P. (2014). Dynamic linkage between real exchange rates and stock prices: Evidence from developed and emerging Asian markets. *International Review of Economics & Finance*, *29*, 1–11.

Narayan, P. K. (2005). The saving and investment nexus for China: Evidence from cointegration tests. *Applied Economics*, *37*(17), 1979–1990.

Narayan, S., Sriananthakumar, S., & Islam, S. Z. (2014). Stock market integration of emerging Asian economies: Patterns and causes. *Economic Modelling*, *39*, 19–31.

Nieh, C.-C., & Lee, C.-F. (2001). Dynamic relationship between stock prices and exchange rates for G-7 countries. *The Quarterly Review of Economics and Finance*, *41*(4), 477–490.

Obstfeld, M., & Taylor, A. M. (2003). Globalization and capital markets. M. Bordo A. Taylor & J. Willmson. In *Globalization in historical perspective* (pp. 121–188). Chicago, USA: University of Chicago Press.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, *16*(3), 289–326.

Phylaktis, K. (1999). Capital market integration in the pacific region: An impulse response analysis. *Journal of International Money and Finance*, *18*(2), 267–287.

Phylaktis, K., & Kassimatis, Y. (1994). Does the real exchange rate follow a random walk? The Pacific Basin perspective. *Journal of International Money and Finance*, *13*(4), 476–495.

Phylaktis, K., & Ravazzolo, F. (2005). Stock prices and exchange rate dynamics. *Journal of International Money and Finance*, *24* (7), 1031–1053.

Shiller, R. J. (2005). *Irrational exuberance* (2nd ed.). Princeton, NJ: Princeton University Press.

Shin, Y., Yu, B., & Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. W. Horace & R. Sickles. In *The Festschrift in Honor of Peter Schmidt Econometric Methods and Applications* (pp. 281–314). New York: Springer.

Tiwari, A. K. (2014). The frequency domain causality analysis between energy consumption and income in the United States. *Economia Aplicada*, *18*(1), 51–67.

Ülkü, N., & Demirci, E. (2012). Joint dynamics of foreign exchange and stock markets in emerging Europe. *Journal of International Financial Markets, Institutions and Money*, *22*(1), 55–86.

How to cite this article: Muhammad A, Rubi A, Ismail I, Phylaktis K. Economic integration and the currency and equity markets nexus. *Int J Fin Econ*. 2020;1–24. https://doi.org/10.1002/ijfe.2065

APPENDIX A.

TABLE A1 Variables definitions

No.	Variable Name	Measurement	Source
1	Equity return differentials (ED)	Difference of price adjusted equity returns between the sample market equity return ($P_t = \log(P_t/P_{t-1})$) and the US equity market return ($P_t = \log(P_t/P_{t-1}) * NEX_{i,t}$) in terms of sample market currency, where NEX is the nominal exchange rate, defined as domestic currency per unit of foreign currency. The stock price is in real terms.	Datastream
2	Exchange rate changes (XR)	Log first difference of real exchange rate (REX). i.e., $XR_t = \log(REX_t/REX_{t-1})$. The exchange rate is defined as national currency per unit of foreign currency. For example, for Malaysia, RM/USD. The nominal exchange rate (NEX) is adjusted for relative prices to get REX. For example, $REX_t = (NEX_t)(CPI^{US}/CPI_t^{ML}$, where CPI is consumer price index, superscript US and ML denote US and Malaysia, respectively.	IMF Financial Statistics
3	Real integration (BT)	To gauge real integration balance of trade is scaled on GDP; $BT_{i,t} = \left(\frac{EXP_{i,t} - IMP_{i,t}}{GDP_{i,t}}\right)$, where $BT_{i,t}$ is the trade ratio for country i with the rest of the world, $EXP_{i,t}$ is exports of country i, $IMP_{i,t}$ is imports of country i and $GDP_{i,t}$ is the gross domestic product of country i. This variable captures the openness of an economy and its significant influence will establish the effect of real integration on the currency and equity markets nexus.	Datastream
4	Financial Integration (ID)	To measure financial integration, the real interest rate differential is calculated as the difference between the real interest rate of country i and that of the US (The Asian economies are financially more integrated with the global financial markets rather than with regional economies as noted by Barro & Lee, 2011. Therefore, the US is taken as an appropriate proxy for a global financial market), $ID_{i,US,t} = \left(\frac{IR_{i,t}}{INF_{i,t}} - \frac{IR_{US,t}}{INF_{US,t}}\right)$, where IR_t is interest rate (This paper uses as benchmark the prime lending rate), INF_t is inflation rate, measured by CPI changes.	Datastream
5	Economic activity (EA)	Normalized industrial production index (2005 = 100)	Datastream
6	Financial development (FD)	An index of money supply (M3) to GDP, market capitalization to GDP, and credit to private sector to GDP derived through principal component analysis.	IMF Financial Statistics and Federal Reserve Bank of St. Louis Research Database

TABLE A2 Principal component analysis

	Number	Value	Difference	Proportion	Variable	PC 1	PC 2	PC 3
	Eigenvalues: (Sum = 3, Average = 1)				Eigenvectors (loadings)			
China	1	2.8067	2.6162	.9356	MC	.5563	.8310	.0090
	2	.1905	.1876	.0635	M2	.5879	−.3859	−.7109
	3	.0028	—	.0009	DC	.5873	−.4008	.7032
India	1	2.8636	2.7445	.9545	MC	.5668	.8195	.0849
	2	.1191	.1018	.0397	M2	.5808	−.4706	.6643
	3	.0173	—	.0058	DC	.5843	−.3272	−.7427
Indonesia	1	2.8930	2.7908	.9643	MC	.5708	.7458	.3436
	2	.1022	.0975	.0341	M2	.5743	−.6616	.4821
	3	.0047	—	.0016	DC	.5868	−.0779	−.8059
Korea	1	2.7810	2.5750	.9270	MC	.5590	.7946	.2368
	2	.2061	.1932	.0687	M2	.5773	−.5780	.5767
	3	.0129	—	.0043	DC	.5951	−.1857	−.7819
Malaysia	1	2.8380	2.6837	.9460	MC	.5661	.7626	.3130
	2	.1543	.1465	.0514	M3	.5741	−.6372	.5142
	3	.0077	—	.0026	DC	.5916	−.1114	−.7985
Pakistan	1	2.7792	2.5882	.9264	MC	.5655	.7505	.3418
	2	.1910	.1613	.0637	M2	.5937	−.0828	−.8004
	3	.0298	—	.0099	DC	.5724	−.6556	.4924
Philippines	1	2.8562	2.7343	.9521	MC	.5668	.8219	.0571
	2	.1220	.1002	.0407	M3	.5837	−.3517	−.7318
	3	.0218	—	.0073	DC	.5814	−.4481	.6791
Singapore	1	2.4919	2.0172	.8306	MC	.5108	.8585	.0457
	2	.4747	.4413	.1582	M3	.6041	−.3962	.6914
	3	.0334	—	.0111	DC	.6117	−.3255	−.7210
Thailand	1	2.8925	2.7982	.9642	MC	.5713	.7610	.3074
	2	.0942	.0809	.0314	M3	.5755	−.6385	.5110
	3	.0133	—	.0044	DC	.5851	−.1150	−.8028

Note: The PC refers to the principal component. The PC 1 is selected as it explains the highest proportion.
Abbreviations: Market capitalization/GDP (MC), Broad money (M2 or M3)/GDP (M2/M3), Credit to private sector/GDP (DC). Monetary base is taken as M2 for China, India, Indonesia, Korea and Pakistan and M3 for the rest of sample economies.

TABLE A3 Unit root analysis

	China	India	Indonesia	Korea	Malaysia	Pakistan	Philippines	Singapore	Thailand
I. Level									
ρ	−9.408 (.0000)***	−2.9861 (.0387)**	−10.1 (.000)***	−5.3829 (.0000)***	−0.5285 (.8809)	−5.8223 (.0000)***	−3.2137 (.0213)**	−7.5166 (.0000)***	−1.3479 (.6059)
BT	−4.584 (.0002)***	−4.1183 (.0013)***	−1.8614 (.3497)	−2.7124 (.0745)*	−3.4748 (.0101)***	−5.1526 (.0000)***	−3.6011 (.0069)***	−4.4777 (.0003)***	−3.3023 (.0167)***
ID	−1.4392 (.5613)	−1.5093 (.5261)	−0.9963 (.7535)	−1.4512 (.5553)	−2.2242 (.1988)	−.0818 (.9482)	−2.1553 (.2238)	−3.1606 (.0246)**	−2.5876 (.098)*
EA	−1.8319 (.3637)	−2.6856 (.0794)*	−.0829 (.9481)	−1.9476 (.3098)	0.5556 (.988)	−0.0105 (.9552)	.3995 (.9823)	−1.5134 (.5239)	−2.4272 (.1364)
FD	−2.573 (.1011)*	−1.5806 (.4897)	−1.707 (.4256)	−2.6331 (.0889)*	−1.7805 (.3888)	−0.3389 (.9148)	−1.2999 (.6285)	−2.3571 (.156)	−1.9299 (.3178)
II. First difference									
ρ	−10.9 (.0000) ***	−13.29 (.0000) ***	−9.4 (.000) ***	−10.94 (.0000) ***	−11.11 (.0000) ***	−12.80 (.0000) ***	−10.40 (.0000) ***	−8.572 (.0000) ***	−14.15 (.0000) ***
BT	−12.3 (.0000) ***	−11.49 (.0000) ***	−13.3 (.00) ***	−10.51 (.0000) ***	−18.99 (.0000) ***	−20.85 (.0000) ***	−12.59 (.0000) ***	−13.44 (.0000) ***	−11.57 (.0000) ***
ID	−15.9 (.0000) ***	−6.727 (.0000) ***	−12.8 (.00) ***	−15.20 (.0000) ***	−17.18 (.0000) ***	−14.77 (.0000) ***	−13.61 (.0000) ***	−8.472 (.0000) ***	−16.62 (.0000) ***
EA	−14.3 (.0000) ***	−3.073 (.0312) ***	−9.36 (.00) ***	−10.76 (.0000) ***	−3.692 (.0053) ***	−4.767 (.0001) ***	−3.0959 (.0294)**	−15.68 (.0000) ***	−4.017 (.0019) ***
FD	−6.44 (.0000) ***	−7.319 (.0000) ***	−7.16 (.00) ***	−6.750 (.0000) ***	−4.722 (.0001) ***	−9.730 (.0000) ***	−6.862 (.0000) ***	−5.7 (.0000) ***	−4.706 (.0001) ***

Note: This table reports the unit root results that show some variables are stationary while the others are non-stationary at level. However, all the variables are stationary at the first difference.
***, **, * show level of significance at 1, 5, and 10% respectively.